FOOD HABITS OF RING-BILLED GULLS BREEDING IN THE GREAT LAKES REGION

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The number of Ring-billed Gulls (*Larus delawarensis*) breeding on the Great Lakes has increased significantly during the last 3 decades (Ludwig 1966, 1974). Changes in the availability of nesting sites, fish introductions, and restrictions on human predation are among those factors probably responsible for the population explosion. Additionally, breeding adults may have intensified or perfected their exploitation of food resources not consistently used by the sympatric Herring Gull (*L. argentatus*). Both species consume large quantities of fish, but Ring-bills also actively secure sizeable numbers of terrestrial, aquatic, and aerial invertebrates to supplement their diet, particularly when feeding young. Intensified use of this latter food resource by Ring-bills may have reduced the dietary overlap between Ring-billed and Herring gulls and contributed to population changes. The observations of Pettingill (1958) and Mueller (1965) suggest that the reliance of Ring-billed Gulls on insects as an energy source is a recent innovation. It is possible that gulls capturing aerial insects may have escaped earlier notice by ornithologists, but it is equally plausible that this feeding method was increasing in frequency during these years when the Ring-billed Gull population was enlarging rapidly (Ludwig 1974).

We conducted this study to determine the food habits of Great Lakes Ring-billed Gulls during the breeding season. We have attempted to identify any seasonal and distributional trends in food habits by grouping samples by collection dates and locality. We believe that the degree of resolution provided by our method will be useful in development of an understanding of the ecological involvement of Ring-billed Gulls.

In the only other Great Lakes study, Ludwig (1966) reported that an undisclosed number of samples collected between 1963 and 1965 contained 265 alewives (*Alosa pseudoharengus*), 69 smelt (*Osmerus mordax*), 5 yellow perch (*Perca flavescens*), 5 other fish species (36 individuals) and 15,000 to 20,000 insects. In a later paper Ludwig (1974) further discussed the relative amounts of fish species occurring in samples. Two studies have been conducted at inland lakes in western Canada. Munro's (1936) study, based on 1 collection in May 1933 and 1 in June 1934, indicated that Ring-bills feed on grain, ground squirrels, carrion, ground beetles, and mice, named in order of their importance. Vermeer's (1970) more comprehensive study covered May through July (1964–65) and showed rodents to be an important food item throughout the season, with grain also being important in

May, insects in June, and refuse in July. Significant differences apparently exist between the food habits of Ring-billed Gulls breeding in the eastern and western portions of North America.

METHODS

Food samples were obtained by forcing adults and chicks to regurgitate. Cannon-netted adults and confined chicks often expelled food from the upper digestive tract. Usually an individual regurgitated a single, well defined bolus that we collected and sealed in a plastic bag containing 10% formalin. Most samples obtained after cannon netting were from adults but as we could not discriminate between chick and adult regurgitations late in the nesting season, we referred to each sample from the ground as an "individual sample."

Groups of chicks were confined in a box and transported to a site for orientation experiments. They occasionally regurgitated under these conditions. Food collected from the boxes during one day was combined as a "composite chick sample" because some mixing occurred. These samples each contained food from 15 to 50 chicks.

From May through July 1964, Southern collected samples at a mainland colony near Rogers City, Presque Isle Co., Michigan. All 76 samples were obtained when chicks were several weeks old; 65 (86%) were taken between 29 June and 1 July. Because no attempt was made to collect all available samples and preference was given to samples containing insects, this material is discussed separately.

A more comprehensive study was made from May through July 1971 at 3 Michigan colonies: Rogers City, where 141 individual samples were collected between 7 May (egg-laying stage) and 21 July (hatching peak, 1 June); Ile aux Galets (in Lake Michigan, 11.3 km offshore from Cross Village, Emmet Co.), 80 samples between 9 June and 20 July; and Bird Island (in Lake Huron, about 1 km offshore near Ossineke, Alpena Co.), 11 samples on 17 June. Ten composite chick samples were collected at Rogers City between 2 and 22 June (total = 242 samples). To assist in assessing for seasonal variation in diet, we grouped the individual sampling dates (see Table 1). Data for the 3 colonies have been kept separate as distance from the mainland probably influences foraging patterns.

For analysis each sample was placed on a 40-gauge wire screen, washed with water to remove mucus and to separate food items and drained. Total volume of each taxon per sample was measured to the nearest 0.5 cm^3 by water displacement in a 100 cm^3 graduated cylinder. For each sample we recorded the total number of individuals, volume of each taxon, and collection site and date. Most insects were keyed to family; fish were identified to species. Debris and plant material in samples was negligible except on 7–9 May (Table 1).

RESULTS

Composition of 1964 samples.—An incredible number and diversity of insects were contained in 76 samples; 17,581 individuals representing 12 orders and 80 families (68% of total sample volume). Fish, earthworms, and spiders also were recorded. The percent of total volume and frequency of occurrence, respectively, for the 4 major insect taxa found in over 50% of the samples are as follow: Homoptera—31%, 76% (Cicadidae 19%, 33%;

Cicadellidae 12%, 62%); Ephemeroptera—15%, 55% (mostly Ephemeridae); Hymenoptera—8%, 58% (Formicidae 4%, 50%; Tenthredinidae 3%, 32%); and Coleoptera—4%, 59% (Carabidae 2%, 41%; Elateridae 1%, 38%; Scarabaeidae 1%, 25%).

Fish represented 32% of the total volume. By percent volume and frequency of occurrence, respectively, the most important were yellow perch (11%, 4%), nine-spined stickleback (*Pungitius pungitius*) (4%, 20%), and alewives (4%, 3%). As collecting procedures in 1964 may have emphasized the insect composition of samples, these figures cannot be interpreted as representing the relative importance of fish and insects during the nesting period.

Composition of the 1971 samples.—The content of adult and chick samples from the 3 colonies is divided into taxonomic categories. Numbers following each category indicate the total individuals for that taxon, volume of taxon, percent of total volume and percent of the 232 individual samples in which the taxon occurred. "NA" indicates that the total number of individuals was not determined. The following provide a general overview of the diet of Ring-billed Gulls nesting in the Great Lakes Region:

Annelida (NA, 40.5 cc, 1.1%, 5.2%): Earthworms (Lumbricidae) constituted a major food source for Rogers City Ring-bills in May and early June (Table 1). During this time we also received reports from local farmers of large numbers of gulls feeding in their freshly-tilled fields. After mid-June worms did not appear in food samples. However, once, after a rain in late July, Jarvis observed young (7–8 week-old) Ring-bills picking earthworms from the grass at a Rogers City park. At Ile aux Galets worms were present in only 1 sample (9 June).

Decapoda (NA, 13.0 cc, 0.3%, 1.2%): Occasional crayfish exoskeleton fragments were found.

Ephemeroptera (2834, 90.5 cc, 2.3%, 9.9%): Mayflies represented a comparatively small portion of the total gull diet at Rogers City (1% vol., 5% freq.) but on several occasions they were quite abundant (Table 1). At Ile aux Galets, Ephemeroptera appeared to be a more important food item (4% vol., 20% freq.). Of 31 individual samples collected on 2 July, 14 contained 1500 mayflies (50% of total food items, 48% volume). Most of the recovered mayflies were Ephemeridae (some identified as *Hexagenia* spp.). They were in various stages of metamorphosis (including adults) but most appeared near the emergent stage, suggesting heavy water surface feeding by gulls.

Odonata (19, 4.5 cc, 0.1%, 3.0%): Occasional damselflies and dragonflies (adults, naiads) were recovered. Ten naiads (near emergent stage) were identified as *Ophiogomphus* sp.

Table 1

Percent Frequency (f) and Volume (v) of Most Common Food Items in Ring-billed Gull Regurgitations Collected at Rogers City, Bird Island, and Ile aux Galets (1971)

Sample dates / No. individuals	May 7–9 / 22		June 2–3 / 1		8–12 / 1		9* / 39		15–19 / 60		17** / 11		23–24 / 12		July 1 / 7		2* / 31		7 / 5		12–15 / 21		18–21 / 14		20* / 10	
	f	v	f	v	f	v	f	v	f	v	f	v	f	v	f	v	f	v	f	v	f	v	f	v	f	v
Lumbricidae	45	26	—	17	—	1	3	t	2	t																
Ephemeroptera			—	14	—	t									29	t	45	15			24	3			20	t
Hemiptera			—	t	—	t	33	1	2	t					29	t	35	t			10	t				
Homoptera					—	1	15	t	84	64	91	75	25	12	86	39	19	t	80	68	33	10				
Neuroptera			—	t	—	t	31	t									3	t			10	t				
Coleoptera	27	2	—	9	—	2	44	2	20	2			8	t	29	t	48	1			19	t				
Trichoptera			—	4	—	t	15	t					8	t	14	t	19	t			14	1				
Lepidoptera			—	7	—	1	33	t	2	t			17	1	57	3	55	3			24	2				
Diptera			—	10	—	2	44	3	7	t			17	t	43	1	48	3			14	t				
Hymenoptera			—	t	—	t	13	t	11	1					29	t	29	t			5	t				
Pisces	36	55	—	36	—	91	97	93	27	33	27	25	75	82	43	55	81	74	40	32	67	79	100	100	100	99
TOTAL	—	83[2]	—	97	—	98	—	99	—	100	—	100	—	99	—	98	—	96	—	100	—	95	—	100	—	99

t Designates trace volumes and numbers less than 0.5.
[1] Dates of composite chick samples; these samples are excluded from frequency of occurrence calculations.
[2] Low total volume due to presence of bird bones and egg fragments (8%), Decapoda exoskeleton fragments (3%), and debris (7%).
* Dates of Ile aux Galets samples.
** Date of Bird Island samples.

Orthoptera (1, 0.5 cc, trace, 0.4%): One grasshopper was recovered at Rogers City, but in 1975 Southern noted many in the diet.

Hemiptera (203, 9.5 cc, 0.2%, 12.5%): True bugs regularly included Pentatomidae, Nabidae, and Miridae.

Homoptera (1056, 645.0 cc, 16.7%, 29.9%): At Rogers City, 47% of the individual samples and 50% of the composite chick samples contained cicadas (Cicadidae: *Okanagana rimosa*). They appeared in the diet from 12 June to 12 July but were absent from Ile aux Galets samples. Ten of the 11 Bird Island samples contained 65 cicadas, accounting for 75% of the total volume. According to Moore (1966), this cicada is common to the pine barrens and pine-aspen woodlands on the Lake Huron side of northern Michigan but is unknown from the Lake Michigan shore. The Rogers City area cicada population is fairly regular in appearance with some emerging every year between mid-June and early July, although the life cycle between adult generations requires 9 or 10 years. We often observed large numbers of cicadas (alive and dead) floating in the lake or washed up on the beaches in the Rogers City area. T. E. Moore (pers. comm.) observed gulls taking *O. rimosa* from the ground and the water surface as well as "hawking" them in the air. Cicadas accounted for 25% of the diet volume at Rogers City. Leafhoppers (Cicadellidae) were occasionally present at Rogers City and Ile aux Galets.

Neuroptera (394, 2.0 cc, 0.1%, 5.5%): Virtually all lacewings (Hemerobiidae, Chrysopidae).

Coleoptera (886, 45.5 cc, 1.2%, 24.5%): The Carabidae was the most abundant family at both sites with ground beetles accounting for about 50% of the beetles at Rogers City, and 75% at Ile aux Galets. Next most abundant were Elateridae and Scarabaeidae. Although present in the diet of gulls throughout the sampling period, beetles (adults, larvae) were most abundant in May and early June (Table 1) and probably were acquired by gulls feeding in tilled fields.

Trichoptera (337, 8.0 cc, 0.2%, 8.7%): Most caddisflies were identified as Limnephilidae.

Lepidoptera (886, 38.5 cc, 1.0%, 18.0%): Moths were the only Lepidoptera recovered and most were members of the Noctuidae.

Diptera (4258, 57.5 cc, 1.5%, 19.3%): Chironomid midges, primarily *Chironomus* sp. in the pupal stage, were the most abundant dipteran at both colonies but particularly so at Ile aux Galets. Frequently mayflies and midges occurred in the same sample. Next most abundant were Anthomyiidae, Syrphidae, and various cycloraphan muscoids. Young Ring-billed Gulls, 5 weeks old and older, commonly turned over dead gull chicks in the colony and consumed fly larvae.

Table 2

Mean Percentage Volume of Insects and Fish in Individual Ring-billed Gull Regurgitations at Rogers City and Ile aux Galets (1971)

ROGERS CITY

Sample dates No. individuals	7–9 May 22	15–19 June 60	23–24 June 12	1 July 7	7 July 5	12–15 July 21	18–21 July 14
Insects	trace[1]	89[2]	18	77	74	34	0
Fish	27[3]	11	80[3]	23	27	65	100[3]

ILE AUX GALETS

Sample dates No. individuals	9 June 39	2 July 31	20 July 10
Insects	4	20	trace
Fish	95[3]	76[3]	100[3]

[1] Balance of contents composed of earthworms (32 mean % volume—significantly greater than for insects for sampling period), egg fragments, bones and debris.

[2] Sample volume significantly greater than for fish for indicated sampling period.

[3] Sample volume significantly greater than for insects for indicated sampling period. Statistical significance ($P < 0.05$) determined by one-way analysis of variance on arcsine transformation equivalents.

Hymenoptera (185, 6.5 cc, 0.2%, 11.2%): Ants (Formicidae), largely winged, were most abundant with tenthredinid sawflies and ichneumonid wasps also being present.

Fish (689, 2915.5 cc, 75.5%, 62.2%): At Rogers City, 41 of the 141 individual samples contained smelt (77, 542.4 cc), 31 had alewives (62, 502.5 cc) and 20 included sticklebacks (172, 191.5 cc). Of the 80 individual samples from Ile aux Galets, 36 contained smelt (87, 672.5 cc), 30 included alewives (52, 397.0 cc) and 24 had sticklebacks (162, 161.0 cc). In the combined Rogers City samples, there were 4 yellow perch and 6 cyprinids; at Ile aux Galets there were 5 minnows.

Alewives and smelt consistently occurred in samples throughout the study, although smelt appeared to be the more abundant in May and June, and alewives predominated in July. Sticklebacks were most numerous in mid-July and ranked close to smelt in volume for the entire month of July.

Birds and bird eggs (NA, 9.0 cc, 0.2%, 0.8%): On 9 May at Rogers City, 1 sample contained gull egg shell and membrane fragments and another sample contained some bird bones of uncertain origin.

On numerous occasions, Southern has observed adult Ring-billed Gulls

eating unattended eggs. Egg contents, because of soft consistency, would not show up during our sampling procedure and so the amount consumed cannot be determined. It is possible that adults observed consuming eggs were not breeding birds.

While banding chicks on Ile aux Galets in 1973, Southern noticed a 10-day-old chick that was apparently choking. Shortly after being picked up, it regurgitated a Ring-billed Gull chick that was about 1-day-old. On this same day, another Ring-billed Gull chick regurgitated 2 altricial nestlings, probably Red-winged Blackbirds (*Agelaius phoeniceus*). A few blackbirds nest on the island.

Mammals: In mid-May 1974, a vole (*Microtus*) was regurgitated by an adult Ring-billed Gull at the Rogers City colony. This is the only time in 12 years of cannon netting that Southern obtained evidence of this species feeding on rodents. Apparently this food source is exploited less in the Great Lakes Region than by Ring-billed Gulls in prairie regions of western Canada (see Vermeer 1970).

DISCUSSION

The mean percentage volume (Table 2) of earthworms, insects, and fish in Rogers City individual samples differed as the season progressed. Earthworms were the major food item in the May samples with fish ranking second and insects last. During 3 periods in June and July, insects were the major food item. The volume of insects increased from a trace in May to 89% on 15–19 June and ranged from 18 to 77% through 12–15 July (Table 2). Insect groups accounting for substantial percentages of total food volume were cicadas, mayflies, beetles, and dipterans (Table 1). Insects were present in 64% of the samples from all 3 colonies and represented 22% of the total volume of chick and adult samples. Smaller quantities of earthworms and insects were found in the Ile aux Galets samples suggesting that gulls at offshore colonies have less opportunity to exploit these food sources.

Fish were recorded during all 7 sampling periods although there were but 3 periods when fish composed the greatest sample volume. Smelt, alewives, sticklebacks, and unidentified fish flesh provided 76% of the total food volume and were present in 61% of the samples. Smelt decreased in frequency as the season progressed: May, 39% of volume; June, 45%; and July, 23%. This reduction may be associated with seasonal patterns of smelt movement between deep and shallow water (Lackey 1970). In contrast, alewife consumption increased as the season progressed: May, 4% of volume; June, 15%; and July, 37%. This could also be associated with spawning and seasonal movement patterns (Galligan 1962, Norden 1967). The proportion of alewives

recorded during our study was less than reported for the mid-1960's (see Ludwig 1966), presumably because of a reduction in alewife abundance.

The quantity of sticklebacks in samples increased in late June, and during July represented 20% of the total volume and 71% of the total number of fish. McKenzie and Keenleyside (1970) reported that sticklebacks breed in shallow rocky water of northern Lake Huron at this time. Breeding activity in water 25–30 cm deep would make the fish available to gull predation.

At Ile aux Galets the dependence on fish appeared greater (88% of total volume compared to 11% insects). In fact, 71% of the total number of food items were aquatic and constituted 96% of the total volume while at Rogers City, 61% of the organisms were aquatic and represented 83% of the total volume. The greater dependence on aquatic food may be associated with the island colony being located 11.3 km from the mainland. Ile aux Galets birds appear to have a more diverse diet. Thirteen of the 20 major food categories were found in 10% or more of the individual samples while at Rogers City only 5 of the food categories were present in 10% or more of the samples.

In addition to seasonal variation, there is evidence of considerable daily variation. Time of day appeared to be correlated with the presence or absence of particular items. Although an accurate record was not maintained as to time of sample collection, general observations suggested a predominance of fish in early morning collections. Lower early morning temperatures probably made insects less available and increased the rate of fish capture. Therefore collection time could bias conclusions regarding food habits.

Weather conditions apparently influenced the availability of particular food items. For example, at Rogers City, mayflies were present in samples on 44% of the clear to partly cloudy days (< 50% cloud cover) and on only 14% of the overcast days (> 50% cloud cover). Neuropterans were present on 56% of the clear days and on only 14% of the overcast days. Lower temperatures and/or rain often accompanied overcast conditions and probably reduced the amount of insect activity. Under such conditions, Ring-bills showed increased use of fish. Alewives were present in samples on 78% of the overcast days but only 44% of the clear days.

In Ring-billed Gull food samples collected from 1963–67 at breeding colonies in lakes Michigan and Huron, Ludwig (1974) found 71% of the fish to be alewives, 20% smelt, and 9% various other fishes. He (1966) estimated that alewives provided 50–60% (wet weight) of the Ring-billed Gull's diet. Our 1971 data show that alewives constituted only 20% of all fishes eaten (24% of the total food volume); smelt, 27% (36% total volume); and sticklebacks, 50% (9% total volume). Although wet weight and volume are not comparable, our findings are substantially different from Ludwig's.

A possible factor underlying the differences between Ludwig's findings and ours could be the size of the various fish populations in the lakes. Smith (1970) reported a sharp decline in smelt and yellow perch in Lake Michigan as alewives became abundant in the late 1950's and mid-1960's. The smelt decline was at least partially a result of alewife predation on smelt fry. After the alewife population peaked, in about 1964 (Berst and Spangler 1973), smelt began to increase and presumably continued to do so after termination of Smith's study in 1968. If so, this could account for the larger proportion of smelt recorded during our study.

Smelt were originally established in the upper Great Lakes around 1923 as a result of introductions in Crystal Lake, Michigan from where they subsequently entered Lake Michigan. They were first noticed in Lake Huron at a point off Rogers City in 1925 and by 1941 they were known to visit every stream along the entire Georgian Bay during the spawning runs (Dymond 1944). After a massive dieoff in the early 1940's, prior to the alewife explosion in Lake Michigan, the smelt population was on the increase, although not nearly as rapidly as that shown by alewives in the 1950's and 1960's (Smith 1970). Perhaps the smelt introduction played a role in the pre-1940 reestablishment of the Ring-billed Gull as a successful breeding species on the Great Lakes (Southern 1974). The later abundance of alewives probably contributed to the more recent population increase as proposed by Ludwig (1974). As the Ring-billed Gull population has enlarged faster than that of the sympatric Herring Gull (Ludwig 1966), it is plausible that factors in addition to the availability of fish have contributed to the differential rate in population growth. From our findings on food habits, it appears that one of these factors may be the Ring-bill's supplemental dietary use of earthworms and insects during the nesting season. This additional energy source also may be of importance in maintenance of the present population.

Further changes in gull populations may occur as alewife and smelt populations respond to introductions of various predatory fishes, including coho salmon (*Onchorynchus kisutch*), chinook salmon (*O. tshawytscha*) and the resurgence of lake trout (*Salvelinus namaycush*).

SUMMARY

Regurgitated food samples were collected from Ring-billed Gulls at 2 breeding colonies on Lake Huron and 1 on Lake Michigan during May through July of 1964 and 1971.

Fish comprised 76% of the total diet volume, insects 22%, and earthworms 1%. By frequency of occurrence, fish appeared in 61% of the individual samples, insects in 64%, and earthworms in 5%. Frequency and volumetric data are provided for each major taxon.

Changes in diet were noted as the breeding season progressed. In May, June, and July, fish constituted 56%, 72%, and 84%, respectively, while for the same 3 months insects accounted for 2%, 28%, and 16% of the volume. Earthworms contributed 26% of the

total May volume but declined to 1% in June and nothing in July. Food types in samples were indicative of aquatic, aerial, and terrestrial foraging. Food habits are discussed in relation to gull population dynamics on the Great Lakes.

Dietary differences were noted between gulls nesting at mainland and offshore sites. Fish accounted for 69% of the volume at Rogers City and 88% at Ile aux Galets; insects contributed 30% of the total volume at Rogers City and 11% at Ile aux Galets. There was a greater diversity of food items in the Ile aux Galets samples as well as a larger percentage of food of aquatic origin. The periods of peak abundance of the 3 fish species in the samples roughly coincided with the respective spawning seasons.

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